DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS
WASHINGTON

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Technical News Bulletin No. 28

GENERAL NOTE

The Bureau has received a number of inquiries based upon this Bulletin, requesting copies of publications on the subjects treated. Generally speaking, such publications are not available, since the investigations reported in these bulletins are of a current character and the work is ofttimes progressing more rapidly than can be followed in any formal publication. The intent of these announcements is that technical men interested in the lines of work treated, may have opportunity to get in touch, whether by personal conference or by letter of inquiry, with the work going on, and obtain such specific data as may be needed for their particular purposes. Publications will, of course, be gladly supplied when the information desired is available in that form. Inquirers should give the fullest possible details regarding the use which is to be made of information requested in order that the compilations required may be prepared in such a manner as to be most economical and effective.

1 Investigation of Railroad Bridge Failure

Studies of specimens taken from a railroad bridge in the middle west, which failed recently, showed evidence of poor design in extremely close rivet spacing. It was apparent that the material had been excessively stressed on numerous occasions, as evidenced by the elongation of crystals parallel to the line of stress, together with an increased proportional limit of elasticity for a part of the materials. The bridge, which was constructed some 30 years ago, was obviously designed for lighter loads than those prevailing today, and the rivet spacing was about 20 percent. closer than is now prescribed as a standard minimum by one of the most important structural manufacturing organizations.

2 Concrete and Other Building Materials

Concrete building blocks faced with marble were tested for strength, security of bond, and resistance to the action of frost. The results of this work showed that blocks of this character are suitable for use in construction. They are of some importance in that they will permit of the utilization of waste marble, at the same time affording a very attractive facing material.

Coquina shells from Florida were tested to determine their suitability as aggregate in concrete. While the resulting concrete was inferior to that made from Potomac River sand, it will be satisfactory for some purposes.

Cement tested during the month of July involved over

227,000 barrels, all of which was shipped for use on various government projects. For failure to meet the requirements of the specifications, 5,000 barrels of cement were rejected.

3 Adhesion Between Brick and Mortar

The theory has been advanced that the strength of a brick wall or pier depends not only upon the strength of the individual bricks and the mortar, but also upon the adhesion between the mortar and the brick. At the request of the Sand Lime Brick Association, the Bureau has given some investigation to this question and the results have shown that the bond depends largely upon the number, size, and shape of the pores upon the surface of the brick. It is possible for the manufacturer of such brick by proper control of his process, in relation to the consistency of the raw mix and of the pressure used in molding, to produce pores of such shape as to increase the adhesion of mortar to the brick to a maximum value.

4 Thermal Expansions of Porcelain, Insulating Compositions, Marble, etc.

A paper has been sent to the press giving data on the thermal expansion of the materials named. The Bureau's ceramics laboratory has produced porcelains having coefficients ranging from 2 to 20 microns per meter per degree C. This paper points out the necessity for considering the exact form of expansion curves when matching metallic electrodes to insulators, as in spark plugs, etc. Most metals expand at an increasing rate as the temperature is raised, whereas in a few specimens of porcelain the reverse is true. It therefore becomes evident that the average coefficient of expansion is not a sufficient criterion for the safe assembly of this class of porcelain with metals, and in many cases it is necessary to know the nature of the change in the coefficient of expansion as the temperature is raised.

A comparison of the coefficient of expansion for marble indicates a large variation among the specimens from the New England States as compared with those from Tennessee and Georgia. Marbles of different color are often assembled in structures subject to large changes of temperature, and if proper attention is not given to the matter of providing cement which is not too rigid, or where the seams formed due to unequal expansion of material are not protected from weather, ice, or even dirt, the working to and fro of the marbles having different expansion properties will eventually cause failure. It is now believed that the disintegration of many masonry structures can be closely associated with this phenomenon.

5 Leather and Rubber Investigations and Testing

A technologic paper on the effects of oil and grease and the degree of tannage on the physical properties of russet harness leather is in preparation. Samples of materials recently tested for the various government departments include harness and special chrome leather, pneumatic tires and tubes, suction pipe sleeves for dredges, canvas belting, rubber covered wire, asbestos gaskets, and water hose.

6 Calculation of Optical Lens Systems

This investigation is being renewed after several months' unavoidable interruption, in the hope of developing a simplified system of preliminary calculation of optical systems.

To obtain instruments of highest grade performance, the computation of compound lenses - such as are used in cameras, microscopes, telescopes, binoculars, range-finders, etc.,- involves the refractive indices of usually at least two kinds of glass, the curvature of the faces of each lens, the thickness of each lens, and the distance apart of the separate lens. A change of any one of these factors necessitates a compensatory change in all the rest, so that the problem of design is an extremely complicated and tedious one, requiring an enormous amount of mathematical calculation. The object of the present investigation is to diminish the amount of preliminary work in designing the simplest systems by providing charts and tables for the approximate errors of single lenses, and for double lenses either in contact or separated. This substitutes interpolation in a single table for the use of a large number of logarithms.

7 Testing of Photographic Lenses

In connection with the performance testing of photographic lenses, a new "target" has been prepared, comprising a large number of specially designed 4-inch test charts, consisting of radial black lines (on a white background) whose width gradually diminishes toward the center of the chart. A photograph of the target, the image of which covers the working field of the lens under test, is taken. In the photograph each chart appears blurred near its center where the lines are too near together to be "resolved" by the lens. The radius of the blurred region of each test chart shows how close and narrow a line the lens will resolve, and is hence a ready measure of the degree of definition furnished by the lens for lines lying in various directions at the particular part of the field where the 4-inch chart is located. This arrangement permits of the immediate reading of the radius of blur and in this manner comprehensive service tests of photographic lenses can be made very rapidly, and an accurate and reliable estimate made as to the general excellence of the lens. This forms a part of the low

cost performance test which the Bureau is developing for testing of photographic lenses, so that a reliable test may be available for the general public at a moderate expense.

8 American-made Refractometer

Probably the first refractometer of the Abbe type manufactured in the United States has recently been tested at the Bureau. The Bureau cooperated with the manufacturer of this instrument by consultation and advice on details of the design, testing of the components of the instrument during its design and manufacture, and finally, by a comprehensive test of the completed instrument. It was found that the new instrument can be more conveniently manipulated, will measure refractive indices (refracting powers of solid and liquid substances for light rays) more accurately than the same instrument as formerly manufactured in Germany. This new design places the Abbe Refractometer in a higher class as regards precision and adaptability than it has heretofore occupied.

9 Aeronautic Instruments

An investigation is being carried out on the barograph used by Major Schroeder in his recent altitude record flight at Dayton, in order to determine the effect of low temperature on the reading of the instrument. This temperature factor becomes a matter of some importance in high altitude flying, since the compensation for temperature variations as comprised in the instruments themselves, can only be an approximate one.

Through the courtesy of the American Expeditionary Forces, a consignment of German aeronautic instruments, including altimeters, tachometers, air speed indicators, compasses, gyroscopic inclinometers, pressure gages, and gasoline level gages, has been received for purposes of study and comparison. A collection of photographs illustrating in detail the methods used in testing aeronautic instruments at the Bureau has been prepared for use in connection with a travelling exhibit of the work of the Department of Commerce.

10 Properties of Electrical Conductors Carrying Alternating Currents

The calculation of the resistance of electrical conductors when the current is changing is a much more difficult matter than for conditions of steady current flow on account of the magnetic interaction of the different parts of the current. For example, the resistance of a conductor for currents of high frequencies, such as are used in radio practice, will be many times greater than for currents of the low frequencies used in ordinary power house circuits. Another case in which the question of current interactions

is of great importance, is in interference between power circuits and telephone lines. On account of the industrial importance as well as the scientific interest of these problems, much labor has been devoted to the derivation of formulas for calculating the properties of conductors when used for currents of different kinds. There are many important practical cases for which no satisfactory formulas are available.

The inductance and capacity section of the Bureau has just completed a paper on an integration method of calculating the resistance and inductance of conductors, in which integral equations are used instead of the older method of differential equations. The method has been applied to cases adapted to testing the accuracy of results and the practicability of the method, and a satisfactory agreement has been obtained. The method was then extended to cover a case of important practical application for which no formulas were hitherto available, that of two long straight cylindrical conductors constituting a going and returning circuit. The formulas desired were successfully developed and subsequently confirmed by experimental data.

11 Inspection and Life Tests of Incandescent Lamps

The total number of lamps offered for delivery to the Government purchasing authorities during the past fiscal year was over 5,000,000, of which about 600,000 were rejected on the initial inspection at the factory, which covers the mechanical qualities of the lamps and their rating in regard to power consumption and efficiency. In this initial inspection, samples are selected for the burning, or so-called life tests. During the year nearly 3,500 lamps were subjected to this life test and with few exceptions, the tungsten lamps, both vacuum and gas filled, supplied under government contracts, had a life considerably in excess of the 1000 hours of burning required by the standard specifications. At the request of the General Supply Committee, tests were made in connection with bids of various manufacturers for the contract for the next fiscal year, and a considerable range in quality among the lamps submitted was indicated. It is probable that the information obtained by these tests alone repays the total cost of the lamp work for the year.

12 Developments in Radio Apparatus

The development of the electron vacuum tube is rapidly replacing the old-time noisy generators used to produce radio waves, and on account of its many advantages, including the production of continuous waves, which greatly reduce interference, it is in a large measure revolutionizing radio communication. However, the development of such a new device invariably carries with it a great number of technical problems, one of which, in this case, is the determination of the power output and the general behavior of the tubes from the

characteristics which are readily subject to measurement. A scientific investigation by the Bureau has yielded methods by which this can be done. In the practical use of electron tubes as generators a direct current source of power is required, and as batteries or machines to produce the high and unvarying voltages are not available commercially, the Bureau was requested to perfect some means of obtaining the type of current required. This was done by using similar electron tubes as rectifiers, supplied with alternating current. Difficult special investigations were necessary in order to remove some of the difficulties, such as the slight pulsation of the rectified alternating current. The application of this work was principally in the field of radio telephony, in which the relatively feeble waves must be converted, by means of a high power amplifier, into the very powerful waves required for telephoning long distances. New methods of applying high power tubes as amplifiers were successfully worked out to meet this need.

13 Investigations on the Radio Direction Finder

A study has been made of the errors in the use of the radio direction finder due to the distortion effect of buildings and large natural objects. It was found that non-metallic objects, such as banks of earth, a brook, a gully, or a tree, do not seriously affect the indications of the direction finder, although they change the apparent direction a few degrees when close by. Metallic objects, however, such as a water tower, a bridge, a tuned aerial, or a trolley line, cause large errors, changing with the location of the direction finder and with the wave length that is being received. This effect is due to the currents produced in such objects by the radio waves, which become large and have a powerful effect on a nearby direction finder when the natural wave length of the object is the same as that of the received wave. Special studies were made in the vicinity of the Washington Monument, the steel elevator shaft of which makes it in effect a metallic tower 550 feet high. Moreover, there are no trees, buildings, or other large objects in the near vicinity. Direction errors as great as 90° were found for wave lengths close to the natural wave length of the Monument, falling off rapidly when the wave lengths were less than one-half or more than twice this value.

14 Corrosion of Electric Cables

A peculiar case of corrosion of lead cable sheaths used by a St. Louis power company was investigated, in which it was found that the difficulty was probably due to a combination of several causes, chief of which was the subjection of the cable system during its first few months' use to very high positive potentials. Subsequently failures gradually developed, due particularly to the elevated temperature at which the cables were operated and to the peculiar type of conduit used.

15 Electrolysis Surveys and Experimentation

A study is being made of improvements possible in the methods of carrying out the surveys leading up to the work in mitigation of electrolytic corrosion, and particular attention is being given to the methods of measuring the current flowing in pipes and the leakage of current from pipes, to replace the old method of measuring differences in voltage between the metal structures concerned. A number of instruments have been built and having given satisfactory results in laboratory tests, they will be tried out under field conditions during the next few weeks. Because of the contradictory character of the evidence as to the conditions under which corrosion of lead cable sheaths occurs, it has has been necessary to carry on a great deal of laboratory work, as, for example, to determine the variation of corrosion with varying current densities in earth, sand, and water. In agreement with previous results, it has been found that the corrosion per unit of current is greater when the actual current density is small. Experiments have been carried on to simulate the condition which occurs when parts of piping systems are alternately positive and negative so that at times the current flows into and at other times out of the metal. The relative amount of corrosion has been found to decrease very rapidly when the portion of time during which the specimens are positive is decreased, and it appears probable that in such cases some of the metal is actually redeposited on the specimen when the current is reversed, although it has not yet been possible to prove this conclusively.

16 Electric Battery Investigations

Particular attention has been given to the study of the manganese ore used in dry cells, a material of which the supply was cut off during the war and which is still difficult to obtain. Through the kindness of a manufacturer, a machine has been obtained for making the dry cell "bobbins" from ores which are analyzed and ground at the Bureau, thus permitting the correlation of results obtained in our examination of the materials with the performance of the product turned out by the factory. The results, though incomplete, have already proved to be of considerable importance. Additional work is being done on methods for determining small amounts of nickel, cobalt, iron, aluminum, and silicon, in manganese ores.

In the investigation of storage batteries, particular attention has recently been given to methods of measuring the performance of positive and negative plates. It was found that in some kinds of batteries an excess of capacity existed in one plate, as compared with the other, implying a direct loss of efficiency in the use of material. In connection with these studies, an investigation has been made of the methods of measuring the plate potentials separately, in particular, by use of the cadmium electrode,

and a paper on the subject has been prepared. Methods for determining nitrites and nitrates in storage battery acids are also being prepared for publication.

Sometime ago a manual on "The Use and Care of Storage Batteries" was prepared by the Construction Division of the Army, and since that Division is not now able to publish the manual, arrangements are being made to issue it as a Bureau circular. The Bureau has also assisted the War Department Committee on Education and Special Training in preparing the manual on storage batteries for use in the educational work carried on by that Committee.

17 Fire Prevention Investigations

At the request of the Bureau of War Risk Insurance, a detailed inspection was made with respect to the fire hazard involved in the buildings and occupancy of the Bureau named, and a detailed report was rendered in which the safe storage of documents, measures relating to fire prevention, adequacy of exit facilities, etc., were fully discussed.

18 Temperature Measurements

Nearly 1,600 thermometers of various types were tested during the month of July, including, clinicals, and clinical standards, laboratory and platinum resistance thermometers, and thermo-hydrometers. In addition, a number of rare metal thermocouples, potentiometer indicators, observation glasses, an ammeter for an optical pyrometer, and a Wanner pyrometer, were tested, and 5 melting point determinations were taken on gold and bronzes.

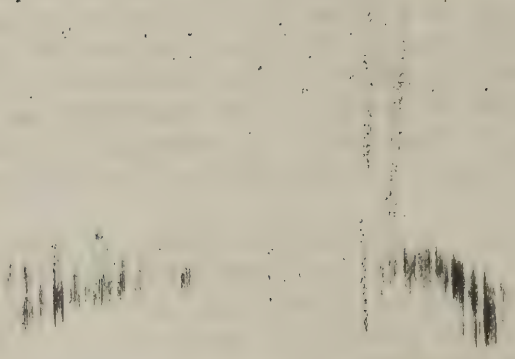
19 Pressure Drop in the Air Tubes of Airplane Radiators

The pressure drop in the air tubes of radiators has a controlling influence on the head resistance of the radiator core. A series of experiments has just been completed in the 54-inch wind tunnel of the Bureau, as a result of which the pressure gradient has been determined for the air tubes of three widely different specimens of radiator core. It has been found that the pressure gradient is practically independent of the character of the tube surface for the range of smoothness or roughness usually encountered in high-grade airplane radiators. In one radiator section, however, which had abnormally rough surfaces, the pressure gradient was about 30 percent. greater than in a section of similar dimensions with fairly smooth tubes.

20 Lubrication Investigation

The preliminary work in connection with the engine testing of lubricating oils, including friction horsepower runs with various water and oil temperatures, has been completed. The examination of the oil samples, taken for comparison with the original oil, is well under way. The tabulation of the physical properties of brands of oils which have been examined in the laboratory, is being prepared for publication.

Important steps have been made toward determination of the value of emulsion tests for automobile lubricants, and



it is expected that some results will soon be published. Much work has been done on the oxidation oven for the Waters carbonization test and the operation of the apparatus greatly improved. Experiments on the gasoline-absorbing properties of lubricants are being continued.

21 Munitions Gage Testing

A total of 453 thread, profile, plane, and precision gages were tested during the month at the Washington laboratory of the Gage Section, and 116 at the New York City laboratory. Toward the end of the month, the New York branch laboratory was discontinued.

A 35-page communication, B523, on thread-measuring formulas and the measurement of pitch diameter, has been prepared and is expected to be ready for distribution in a short time. Another communication of the Gage Section which has recently been issued, gives a list or index of the communications on gage work issued to date.

22 Lead Antimony Alloys

Lead for use as pipe conduits, storage battery plates, etc., is commonly hardened by the addition of small percentages of antimony. As a contribution to the study of lead as used in storage battery plates, the Bureau has determined the tensile strength properties of a series of lead-antimony alloys having an antimony content varying from 0 to about 14%. As the technical literature contains but little information on the subject, the results will be of considerable value.

23 Dental Amalgams

The Bureau has recently issued a brief communication giving the major results of the research on dental amalgams used for tooth fillings. The principal points of note are (1) the tendency of a few amalgams to contract on setting or crystallizing, thus producing a void between the filling and the tooth; (2) the tendency of certain amalgams to change their shape by a slow flow under the continued action of a light pressure, a phenomenon which probably accounts for many cases of recurrent decay or "upsetting" of fillings. The manufacturers of amalgams are being informed of these findings so that they can take steps to correct the defects in their product. On account of the considerable difficulties involved in detecting these faults, they have been somewhat neglected in the past, this being due to the necessarily small size of the specimens, which makes the changes in dimension that occur very difficult to detect and differentiate.

24 Deep Etching of Steel

One of the subjects most discussed at the general meeting of the American Society for Testing Materials, was the deep etching of rails, i.e., the effect of prolonged immersion in concentrated acids. Although this process has been used for some time as a routine method of metallographic examination, there appears to be considerable difference of opinion as to the significance and

interpretation of the results. A rather comprehensive study of the subject has, therefore, been started, which, it is hoped, will demonstrate the effect of such factors as chemical inhomogeneity (segregation), physical discontinuity ("flakes"), spongy spots, porosity, mechanical non-uniformity (internal stresses), etc. This work has only recently been initiated, but may be expected to lead to results of great interest.

25 Mechanical Properties of Materials

At the request of a publisher of a loose-leaf note book system in wide circulation among engineers, permission has been granted for the reprinting of the Bureau's preliminary circular on the mechanical properties of engineering materials. Written requests for copies of this compilation, which at present is in mimeographed form, have been received in considerable number from colleges and universities, government departments, industrial and railroad laboratories, and manufacturing plants.

26 Other Metallurgical Investigations

At the request of the Spanish Embassy, the Bureau has arranged to permit a professor of chemistry of the Spanish University of Oviedo to carry on research work in metallography at the Bureau. Similarly, the request of the Japanese Embassy for a representative of the South Manchurian Railroad to work on a heat treatment problem, has been granted. Other metallurgical investigations in progress, many of which have only recently been undertaken, include studies in the decarbonization of steel during heat treatment in fused salt baths. It may be possible to offset the decarbonization by the addition of calcium cyanimide to the baths. Work is being continued on the general research in substitutes for the so-called "government bronze" to avoid the hard, brittle constituent or "bronzite" which is due to the high tin content. The apparatus necessary for determining the tensile properties of boiler plate steels at high temperatures has been developed to a stage which will permit of carrying on some preliminary determinations. At the request of the manufacturer, an examination was made of specimens of sterling silver teaspoons which showed surface defects. The difficulty appeared to be due to the superficial oxidation of the copper which is added in alloying the silver. Examination of a defective wrought iron chain link showed that the unsatisfactory character of the metal was due to an excessively high phosphorus content.

Respectfully,

S. W. STRATTON

Director

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* Confidential Supplement *

27 Tests of Liberty Airplane Engine Submitted by the Air Service

In connection with an elaborate series of tests of American and foreign aeronautic motors, the Authorities at McCook Field submitted a Liberty airplane engine to the Bureau of Standards, for test in the altitude laboratory. Tests under ground conditions had been made at McCook Field, while at the Bureau the tests included runs with a fully opened throttle under conditions simulating those encountered at the ground level at various altitudes up to 25,000 ft., by steps of 5,000 ft.; propeller load runs every 5,000 ft. to 15,000 ft.; as well as temperature and friction horsepower runs at the ground and 15,000 ft. altitude. The results obtained have been computed and, in the case of tests made under ground conditions, are found to check very closely those obtained at McCook Field. The engine has been returned and will probably be installed in a plane and used as a means of determining propeller efficiency. The altitude laboratory is now being equipped for the installation of a 300 horsepower Hispano-Suiza engine for similar tests.

28 Ignition Systems for Internal Combustion Engines

For some time the Bureau of Standards has used a special form of calorimeter to measure the heat-per-spark of various ignition systems. While the heat-per-spark is by no means a direct measure of its actual igniting power, it does serve as an index of the total power output of any given system, and therefore forms a basis for the further study of the characteristics of ignition apparatus. This calorimeter has recently been reconstructed and recalibrated and heat-per-spark measurements on the Phillips-Brinton ignition system have been completed. Oscillographic tests on this system, are now in progress, by means of which the characteristics of the primary and secondary currents and voltages may be studied. A beginning has been made in the study of eddy currents in magnetos.

29 Aeronautic Instruments

In carrying out performance tests of airplanes in which, for example, the characteristics of a new type of plane are required to be known with considerable accuracy and detail, a permanent record of the readings of the more important instruments such as the altimeter, tachometer, air-speed indicator, radiator thermometer, and the pressure gages, is desired. At the request of the Engineering Division of the Army Air Service, a device involving a motion picture camera of special design is being prepared for use in photographing

the instruments on an instrument board illuminated by incandescent lamps. This will permit of obtaining permanent simultaneous records of the readings of these instruments at chosen intervals from 5 seconds to one minute, throughout the period of the test flight.

30 Wind Tunnel Investigations

The Bureau's Wind Tunnel staff has been occupied for some weeks on a series of tests of a multiplane airplane model, this being a land machine with several wings arranged in three groups in tandem, the fore and aft groups being biplanes, and the middle one a triplane. The work done involved the determination of the static longitudinal stability and the effect of certain changes in the model, such as alteration of the size of wings in the aft biplane group, and of the length of tail, on the stability. The span of the triplane wings of the full scale machine, which has been constructed, is 88 feet, and the power plant consists of three Liberty 12's. This work is being done at the request of the Air Service.

A wind motor for the driving of film cameras on airplanes was tested for the regulation performance of its speed controllers. This motor is essentially an air turbine, which is governed by dampers in the channel in which the motor is mounted. The tests included the determination of the relation between the rotational speed of the motor and the setting of the damper for several wind speeds. A bomb arming vane of the Semple type submitted by the Ordnance Department of the Army was mounted on a Mark I drop bomb in the wind tunnel, and determination made of the speed at which the firing pin was released, both for the forward and for the aft position of the vane with respect to the bomb.

Calibrations of a recording angle-of-attack meter, designed at the Bureau, were carried out. The work done at Lynn, Mass., on the determination of head resistance and pressure distribution of various types of projectiles in the exhaust flow of a high pressure air compressor is now being extended to the lower speed range obtainable in the wind tunnel of the Bureau.

31 Fireproof Airplane Wings

The Bureau has given general consideration to the possibilities in the way of production of fireproof airplane wings. It appears that a corrugated metal wing similar to the German Junker cannot be produced from sheet metal at present available, without exceeding greatly the weights now allowed for airplanes constructed either for the Army, Navy, or commercial concerns. Further investigations are in progress in the hope of securing a more suitable material.

As substitutes for the present fabric covering of wings,- thin sheet metal, sheet metal reinforced by wire mesh, and painted wire mesh are under investigation. The first seems to be excluded by reason of its low tearing resistance, while the addition of the wire mesh as reinforcement to enhance the tearing resistance seems to make a feasible construction, though experimental work is required to determine the best possible means of securing the sheet to the reinforcing mesh. Painted wire mesh is very resistant to fire, and seems to be a promising construction. Experiments are now under way to determine the best material, size of wire, and closeness of mesh, and a manner of applying the paint to secure the required strength and lightness, combined with a suitably smooth surface. In connection with the investigations of transparent wing construction, it has been found that such a provision will be useful only over a limited area near the fuselage. Experiments with available flexible transparent materials show that wire mesh and other reinforcements may be required to afford the desired strength.

32 Structural Parts for Navy Airplanes

Fifteen very large struts for flying boats were submitted to the Bureau for test, to the end of determining whether the designed strength was developed and whether any changes to produce the most efficient strut and spar could be suggested. Considerable variations in strength were exhibited by the specimens, in seeking the cause of which a hundred or more tests were run to determine the quality of the wood used in the construction of the various struts and spars. This showed that there was a wide variation in the mechanical properties of the material, and that a direct correlation existed between the strength of the struts and the mechanical properties of the wood, as those struts which developed the greatest strength were composed of material of exceptional quality. As a result of this investigation a complete report with recommendations and suggestions was submitted to the authorities requesting the test.

33 Measurement of Photographs

At the request of the Ordnance Department, the Bureau aided in an investigation of motion pictures of a falling bomb, these pictures being taken from an airplane over a body of still water. The reflected image of the airplane was easily distinguished in the film. Contrary to expectation, measurements could be made much more precisely on a positive print than on the original film, perhaps because of the difference in texture. It proved to be possible to measure on the image such dimensions as the length and diameter of a bomb and the wing spread of the plane, to .010 to .015 mm. The ballistics of the bomb as deduced from these

measurements check the theoretical values to a fraction of one percent, thus providing in a very inexpensive way accurate data on a subject of great importance.

34 Investigation of New Ordnance Process

To reduce the cost of manufacture, methods of manufacturing guns from a single forging by expanding under a very high internal pressure calculated to produce the required distribution of stress in the wall of the gun, have been devised, this process being known as "auto-frettage", which has been used abroad, particularly in France. At the request of the Ordnance Department of the Navy, a report was made upon certain methods of auto-frettage, including a critical study of the theory involved and of the probable changes which would occur in the metal due to its being over-strained. It is expected that the method will prove to be successful, but more experimental data are needed.

35 Investigation of Copper Crusher Cylinders

This investigation has been continued to include the effect of aging at 0°C and 100°C and of repeated applications of load only slightly exceeding the initial load of compression. In practice the copper cylinders are compressed at a loading somewhat below the estimated pressure in the gun, this pre-compressed cylinder then being used to determine the pressure developed upon firing. Possible dimensional changes in storage, which may last for several years, are being investigated during the aging process. In practice the change in dimensions of the pre-compressed cylinder is taken as an index of the additional pressure to which the cylinder is subjected, e.g., if compressed at 38 000 lb. per sq. in. and fired at 44 000 lb. per sq. in. The tarage table from which this value of the gun pressure is determined is based upon the assumption that only the additional 6 000 lb. per sq. in. (44 000 - 38 000) is effective in producing the increment of change in dimensions. Experimental work has indicated that this is far from a correct assumption.

36 Armor Plate Steels

A study of special steel for armor plate is still requiring the time and attention of several members of the Metallurgical Division in cooperation with the Navy Department, which has arranged for the machining of the plates. Twenty-one finished and treated plates were shipped to the proving grounds for ballistic tests.

Respectfully,

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